Experimentation and Modeling of Hypervelocity Impacts of Spacecraft MMOD Shielding with Incorporated Shear Thickening Fluid

Completed Technology Project (2013 - 2016)

Project Introduction

The student is beginning a doctoral program at Mississippi State University (MSU) with an expected graduation date of December 2015. The proposed research will investigate novel micrometeoroid and orbital debris (MMOD) impact shielding components using hypervelocity impact (HVI) testing and simulation. The shielding components will be constructed from sandwich composites with lightweight porous core materials. The empty spaces of the porous materials will be imbibed with a shear thickening fluid (STF) which displays shear rate dependent behavior wherein their viscosity can increase drastically at a critical shear rate. Three porous materials will be used: 10 PPI 6061-T6 aluminum foam, isocyanate cross-linked amine-modified aerogels, and cross-linked polyimide aerogels. Once the STF's continuous phase is chosen, various shapes and/or aspect ratios of the disperse phase will be investigated. Nano silica particles, vapor grown carbon nanofibers (VGCNF), and graphene or exfoliated clay platelets will be some of the targeted disperse phases. The STF will be characterized using torsional rheometry over a temperature range consistent with that of the space environment. The STF will be infused into the porous materials using processes similar to the full-cell wood impregnation process used in the wood products industry or vacuum assisted resin transfer molding (VARTM) process. A novel STF solvent exchange will also be attempted using the cross-linked polyimide aerogel in cooperation with NASA Glenn Research Center. HVI testing of the STF infused porous materials will be performed using the hypervelocity two-stage light gas guns at the NASA Marshal Space Flight Center as well as at MSU. HVI impact simulations will then be developed using a hybrid finite element material point method and will possibly incorporate peridynamic theory. The proposed research falls under the STR TA12 Materials, Structures, Mechanical Systems, and Manufacturing and the TABS element 12.1 Materials.

Anticipated Benefits

This project investigates novel micrometeoroid and orbital debris (MMOD) impact shielding components using hypervelocity impact (HVI) testing and simulation.

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Table of Contents

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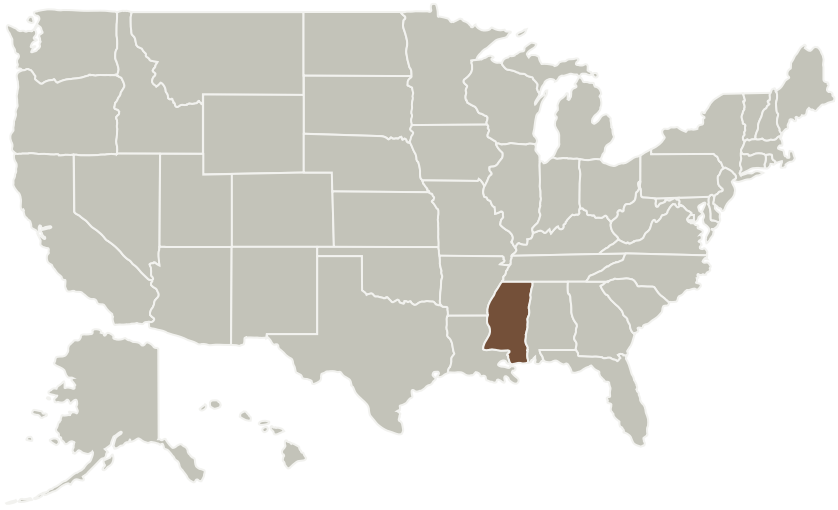
Primary U.S. Work Locations and Key Partners



Primary U.S. Work Locations
Mississippi

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

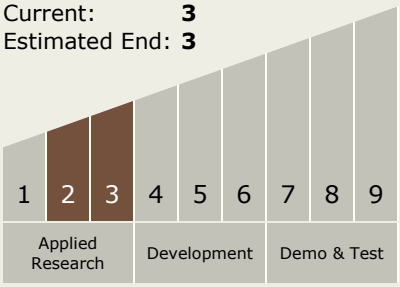
Thomas Lacy

Co-Investigator:

Justin E Warren

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



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Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  - TX12.1 Materials
    - TX12.1.1 Lightweight Structural Materials

Target Destination

Mars